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ABSTRACT

It is possible that the student himself may be a valuable resource in the individualization of instruction in the elementary school. This study paired a fourth grade student with a sixth grade student who had a similar reading skill level. The pair then used a kit of auto-instructional materials designed to teach elementary school science. Students at a control school received conventional instruction in science. The study showed that fourth and sixth grade students can learn from auto-instructional materials without teacher assistance. Analysis of data from the control and experimental students shows that there was no difference between the two groups in relation to achievement levels or self-concept scores. Neither sex, reading level, nor race affected achievement. Only social position affected achievement significantly. The report discusses these and some secondary findings and outlines the research methodology of the study. A reference list is appended. (JY)

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TESTING THE EFFECTIVENESS OF AUTO-INSTRUCTION IN A PAIRED LEARNING ARRANGEMENT

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One resource available for expanding the individualization of instruction in the elementary school is the student. Elementary school students could be used to assist each other in mutual learning tasks through an arrangement of pupils into two-membered teams (pairs). This facet of student team learning has been described as paired learning (Durrell, 1959, 1961, 1962; Durrell & Palos, 1956; Durrell et al., 1959; Hartley, 1968; Hartley & Cook, 1967; Sawiris, 1966). This is not to be confused with the psychological term--paired association.

Paired learning studies may generally be categorized as research in the teaching-learning processes. Tyler (1967-1968) has indicated that few investigations have been undertaken in the teaching-learning processes. Such studies could be valuable in determining how different arrangements of student groups could effectively function to improve various science education programs.

The present study was concerned with comparing certain cognitive and affective performances of a particular group of paired elementary school students with a similar group of non-paired elementary school students. Both groups received identical auto-instructional science lessons on the process of measurement.

THE PROBLEM

The questions specifically asked were:

(1) Will the paired learning treatment differentially influence the

process of measurement achievement scores between the paired versus non-paired groups?

(2) Will the paired learning treatment differentially influence the self-concept scores between the paired versus non-paired groups?

(3) Will the paired learning treatment differentially influence the program completion times between the paired versus non-paired groups?

The general substantive hypothesis was that the experimental group (paired) would produce a greater measurement achievement gain and positive score change on the self-concept measure with no significantly greater program completion time. Rejection of the null form of the substantive hypothesis was to be made at the 95% confidence level.

DEFINITIONS

The experimental operational definitions include:

Manipulative auto-instructional lessons. This term refers to lessons which were designed to be self-taught by a modified linear program. The learner was required to measure objects and record data while completing a 343 frame program uniquely designed for the study.

Science-A Process Approach. The primary objective of this elementary science curriculum project is to develop the child's skills in the basic and integrated processes of science. The project, hereafter referred to as SAPA, is sponsored by the National Science Foundation.

Measurement process. This term refers only to the content of the lessons taught by the auto-instructional program during the treatment period.

The auto-instructional program was used to teach and reinforce one of the eight basic processes of science as described by SAPA. The hier-

archial process development of SAPA was followed, with several deletions. These deletions were necessary to provide for the more advanced utilization of measurement applications. Volume topics, for example, were not developed nor was application made to volume measurement.

METHOD

The Educational Service Center at Royston, Georgia, selected eight schools as representative of Northeast Georgia. The selection included four predominately Negro schools (5 per cent or less white enrollment) and four predominately white schools (5 per cent or less Negro enrollment). Two predominately Negro and two predominately white schools were randomly assigned to one group designated the experimental group. The other four schools constituted the control group.

Individual meetings were held with each of the eight principals of participating schools prior to the study. At that time one fourth grade teacher and one sixth grade teacher were selected by chance in three of the eight schools. There was only one teacher at these grade levels in the other five schools.

In the four experimental schools (N = 169), each sixth grade student was randomly assigned to his partner (fourth grade student) within respective high, medium, and low reading level categories. The control group (N = 158) was composed of the students who worked in their normal classroom situation.

The data on students with a mental maturity score below 70 were deleted from the tabulation prior to the experiment, with several exceptions based on teacher judgment. The assumption was made that these students could not cope with programmed materials. These non-participating stu-

dents were given special lessons by the teachers during the treatment period. Students with missing scores and students who transferred in or out of the schools during the treatment period were also eliminated from the data tabulation, accounting for the uneven numbers in some subsamples.

TESTING INSTRUMENTS

All subjects were administered Gordon's How I see Myself (HISM) scale and a specially designed Measurement Process Achievement Test (MPAT). Social position was determined using the Hollingshead Two Factor Index of Social Position. Other scores obtained from school records included the California Achievement Test Battery and the California Short-Form Test of Mental Maturity.

ADMINISTRATIVE PROCEDURE

Following two pilot trials, the revised auto-instructional materials and criterion test were reproduced for use in the principal study held during February and March, 1969. Preceding the experiment three meetings were held at each of the eight participating schools. The first meeting was held with individual school administrators and the participating fourth and sixth grade teachers. An overview of the study was presented at that time. The second half-hour meeting was held only with the teachers involved in the study. Procedural details were described at that time. The final preliminary meeting was held with students the day before the beginning of the study. A brief questionnaire was administered to the students prior to any discussion regarding paired learning or auto-instruction. During half-hour sessions with the separate fourth and sixth grade classes, the logistics of the class activities were described, followed by a question-and-answer period. The formal talk, which followed

a prescribed outline, was delivered by the investigator to all participating students.

The experiment was initiated the following day by having the teachers administer the MPAT and HISM scale on the same day as pretests. For the next three weeks both the experimental and control groups used the measurement process auto-instructional materials and kits. The sixth grade students in both groups were given red pens to facilitate identification of their papers at a later date. The red pens also asserted the sixth grade student as the senior member of the pair. During the paired learning classes, the sixth grader was required to work with the fourth grader in such a way that he did not advance beyond the fourth grader's answering progress. After reading each frame, the paired students each designated their own proposed answer. The answer was checked and if both students made a correct response, they continued. If one or both students made an incorrect response, the instructions were given that the students should check the frame again and briefly discuss the error. Both students shared one instructional kit, although individual answer sheets were used. Group pacing was reinforced by placing the frame answers in the back of the book and by a special checking procedure required of the sixth grade member of the pair. The experimental group pairs and control group individuals both used 30-50 minute daily instructional periods. Upon the student's completion of the program, the MPAT and HISM scale were again given by the classroom teacher as posttests. The pretest questionnaire was also administered again during the posttest period.

The number of minutes each student worked was recorded daily by the teacher on specially prepared student time sheets. The minutes recorded

were actual working times. The recorded values did not include pretest and posttest time or the starting lesson. The initial lesson consisted of the investigator working through the first 5 frames of Book One with the students. This period lasted about 30 minutes and included instruction regarding: opening and closing the plastic bags containing the materials, constructing responses or recording choices, using review, locating answers and explanations on the four blue answer pages in each book, correcting errors, and progressing at a self-pace. After this initial lesson, the teachers were instructed not to assist the students in any way other than giving work pronunciation or procedural information.

None of the eight schools had any prior experience with Science--A Process Approach. Only one of each of the experimental and control classrooms had a previous experience with programmed materials. Approximately half of the teachers were slightly familiar with the field of programmed learning.

RESULTS

Table 1 gives the results of the analysis of covariance and Table 2 presents certain cell means.

The main conclusions were:

(1) Pairs and individuals achieved at similar levels and displayed similar self-concepts. The pairs required a longer program completion time period.

(2) The sixth grade and fourth grade students did not differ significantly in relation to attained achievement levels or self-concept scores. The fourth grade students required a longer program completion time period.

Table 1.--Analysis of Covariance for Post-MPAT, Post-HISM, and Completion Time Criterion

Source of Variation	df	Post-MPAT	Post-HISM	Completion Time Criterion
Main Effects				
Treatment (T)	1	1.21	0.42	72.59**
Grade Level (GL)	1	0.05	0.01	8.31**
Soc. Position (SP)	2	3.09*	0.76	2.19
Sex (S)	1	0.05	2.47	0.48
Race (R)	1	0.40	2.97	26.59**
Reading Group (RG)	2	1.13	0.86	0.27
Interaction Effects				
T x GL	1	9.91**	1.61	28.59**
T x SP	2	0.41	0.05	1.73
T x S	1	0.89	0.91	2.04
T x R	1	0.56	1.36	1.36
T x RG	2	0.06	0.66	2.02
GL x SP	2	0.25	0.48	0.25
GL x S	1	4.20*	0.37	1.41
GL x R	1	2.14	1.70	0.40
GL x RG	2	0.92	1.51	0.49
SP x S	2	1.30	1.25	1.29
SP x R	2	0.26	1.28	1.65
SP x RG	4	0.70	0.52	2.19
S x R	1	0.03	0.02	2.44
S x RG	2	0.29	0.48	0.41
R x RG	2	0.43	1.77	0.98
Covariates				
Reading level	1	10.79**	0.04	0.00
Pre-HISM	1	0.28	26.31**	0.08
Pre-MPAT	1	22.87**	0.01	3.16
Error	289			
Total	326			

*Significant at 0.05 level ($F_{1,289} = 3.88$, $F_{2,289} = 3.03$, $F_{4,289} = 2.40$)

**Significant at 0.01 level ($F_{1,289} = 6.74$, $F_{2,289} = 4.69$, $F_{4,289} = 3.39$)

Table 2.--Raw Score Means for Post-HISM, Post-MPAT, and Criterion Completion Time (Main Effects)

Source of Variation	Criteria		
	Post-HISM	Post-MPAT	Completion Time
Treatment			
Paired--T_1	128.9	19.9	374.8
Non-Paired--T_2	128.2	18.1	301.5
Grade Level			
6th--GL_1	128.4	21.2	337.4
4th--GL_2	128.7	16.8	352.0
Reading Group			
High--RG_1	129.0	25.2	317.9
Medium--RG_2	129.7	18.4	340.8
Low--RG_3	126.9	13.6	359.4
Social Position			
High--SP_1	129.4	23.9	315.3
Medium--SP_2	128.1	20.9	336.0
Low--SP_3	128.5	15.7	350.2
Sex			
Male--S_1	126.9	18.8	335.7
Female--S_2	130.0	19.2	342.7
Race			
White--R_1	128.1	21.7	314.2
Negro--R_2	129.2	14.9	378.6

(3) The high social position students achieved at a significantly higher level than the low social position students. The high, medium, and low social position students did not differ significantly in regard to self-concept or program completion time criterions.

(4) Boys and girls achieved at similar levels, displayed similar self-concepts, and required similar program completion time periods.

(5) Negro and white students achieved at similar levels and displayed similar self-concepts. The Negro students required a longer program completion time period.

(6) The high, medium, and low reading groups achieved at a similar level,displayed similar self-concepts, and required similar program completion time periods.

The interactions of the main effects were:

(1) A significant treatment by grade level interaction indicated the treatment was differentially effective in favor of the experimental sixth grade group on the achievement criterion.

(2) A significant grade level by sex interaction indicated the sixth grade girls achieved at a higher level than the sixth grade boys. The order was reversed at the fourth grade level.

(3) A significant treatment by grade level interaction on the program completion time criterion indicated the experimental sixth grade students required a longer program completion time than the control sixth grade students. The experimental fourth grade students also required a longer program completion time than the control fourth grade students.

(4) All other main effects interactions were non-significant.

The analysis of the covariables suggested:

(1) Reading level and measurement pretest were reliable predictors of measurement achievement following auto-instruction.

(2) Self-concept pretest was a reliable predictor of self-concept following auto-instruction treatment.

(3) Reading level, measurement pretest, and self-concept pretest were not reliable predictors of the program completion time for auto-instructional treatment.

The analysis of the supportive data suggested:

(1) Fourth and sixth grade students can learn from auto-instructional materials without teacher assistance.

DISCUSSION

The general substantive hypothesis was that the experimental group (paired students) would produce a greater measurement achievement gain and positive scores change on the self-concept measure when compared to the control group (non-paired students). The general research hypothesis was tested through six null hypotheses. Each null hypothesis required more than one test for possible rejection or non-rejection at the 0.05 level of significance. The six hypotheses tested three criterion scores (post-MPAT, post-HISM, and program completion time) with six factors (treatment, reading group, grade level, social position, race, and sex) and three covariables (pre-MPAT, pre-HISM, and reading level).

Data analysis indicated the experimental group did not differ significantly from the control group in relation to the criterion post-MPAT ($F = 1.21$; $p < .05$) or criterion post-HISM ($F = 0.42$; $p < .05$). The treatment did result in a highly significant difference in relationship to the program completion time criterion ($F = 72.59$; $p < .01$). The experimental group required 374.8 minutes for program completion and the control group required 301.5 minutes for program completion.

Paired learning experiments (with auto-instruction) involving an achievement criterion have resulted in mixed findings. Several investigators (Dick, 1965; Durrell, 1961) indicated a significantly different achievement gain in favor of paired learning. Hartley and Cook (1967) and Sawiris (1966) reported no significant difference between paired versus non-paired students although findings were not conclusive. Sawiris used a critical ratio test ($t = 1.98$) which approached significance ($t = 2.0$; $p = .05$) while Hartley and Cook found one significantly different pairing method among six different methods.

The MPAT gains were highly favorable for all treatment x grade level categories ($t < 2.36$; $p < .01$). The evidence suggested that both the fourth grade students and sixth grade students successfully learned from the same auto-instructional materials. Others (Skelton, 1968; Thomas, 1957) have reported success in auto-instructional materials equivalent to the success of conventional instruction or significantly above conventional instruction (Keislar & McNeil, 1961; Hedges & MacDougall, 1964).

The achievement gain scores were similar for all but one of the treatment x grade level categories. The experimental sixth grade group mean difference ($D = 13.84$) was substantially above the other mean differences ($D = 10.20$ to 10.86). The lowest gain ($D = 10.20$) was obtained by the fourth grade experimental group. The low finding was in agreement with Hartley and Cook (1967), who found that the low students in a high-low pair did not profit from being paired with high students.

Although there was no significant treatment main effect with the MPAT criterion, a serendipital disordinal treatment x grade level interaction was discovered. The disproportionate success of the experimental sixth grade students was the primary reason for the significant inter-

action. The finding was in agreement with the pilot trial results. Duckworth (1964) indicated Piaget thought the possibility of having children of different ages in a class together might be especially helpful for the older children. Dick (1965) suggested that the success of a paired student could be attributed to pacing control. Kress (1966), however, reported that contrary to expectation, forcing sixth grade students to spend more time on a program did not improve achievement performance.

Social position represented the only significant main effect ($F = 3.09$; $p < .05$) in relation to the post-MPAT criterion. The adjusted means were analyzed by Duncan's New Multiple Range Test because the factor had three levels. The results of the test are presented in Table 3.

Table 3.--Results of Duncan's New Multiple Range Test for the Main Effect Social Position: Post-MPAT Criterion, Adjusted Means

Social Position	SP_1	SP_2	SP_3
	N=47	N=133	N=147
Mean	21.05	19.08	18.15

The findings indicated that there was a significant difference between the high ($\bar{X}_1 = 21.05$) and low ($\bar{X}_2 = 18.15$) social position group adjusted

means on the post-MPAT. Although the means were adjusted from 23.9 - 15.7 to 21.05 - 18.15 through use of the reading level and pre-MPAT covariables, the high minus low difference was still large enough to be significant. An even larger reading group range became non-significant following covariance adjustment. Perhaps auto-instruction and/or auto-instruction with paired learning is more adaptable to high social interactions.

The grade level x sex interaction was significant ($F = 4.20$; $p < .05$) on the post-MPAT criterion. The experimental sixth grade girls scored slightly higher than the experimental sixth grade boys, however the trend was reversed at the fourth grade level. A differential maturation factor may explain the greater success for the sixth grade girls over the sixth grade boys, but the fourth grade reversal is not easily explained. Perhaps the manipulative character of the program was more conducive to motivation among the fourth grade boys.

The non-significance of the reading group, grade level, and race main effects indicated the successful functioning of the covariables reading level ($F = 10.79$; $p < .01$) and pre-MPAT ($F = 22.87$; $p < .05$). The pre-MPAT contributed more as a prediction factor than reading level and pre-HISM. The success of pre-MPAT as the primary prediction factor was expected because the test items paralleled the objectives of the auto-instructional materials. Reading level also functioned as a satisfactory covariable probably because the auto-instructional materials and test required a good reading capability. The combination of the two covariables accounted for the non-significant grade level main effect rather completely ($F = 0.05$; $p > .05$).

The analysis of covariance on the criterion post-HISM resulted in no

significant main effects or interactions. The main effect race approached significance (F = 2.96). An F value of 3.03 was required for significance at the 0.05 level of significance. As would be expected, the pre-HISM (F = 26.31; p < .01) was the best predictor of post-HISM scores. The affective measure (self-concept) findings paralleled the non-significant affective measures of Dick (1965) and Sawiris (1966). Durrell (1961) and Weitzman (1965) reported significant motivation, interest, and attitude changes of experimental students. Reliable affective measures over short time periods are difficult to obtain, which may account for the contradictory research findings. The investigators often resorted to reports of face-validity.

The analysis of covariance for the completion time criterion indicated highly significant main effects of treatment (F = 72.59; p < .01), grade level (F = 8.31; p < .01), and race (F = 26.59; p < .01). The high significance of these main effects suggested an inappropriateness of the covariables for the time criterion.

The experimental group required more program completion time. The fourth grade students probably acted as an external pacing source for the sixth grade students. Sawiris (1966) found no significant time differential in an experimental paired learning study. The Sawiris study was completed with adolescents, not elementary school students, which may account for the different findings.

The fourth grade students required a longer program completion time period than the sixth grade students and the Negro students required a longer program completion time period than the white students. The main effect interactions suggest a common reading differential, but the reading level F value was a surprising 0.00. Apparently the rate at which

students completed the programs was poorly predicted by reading level, pre-HISM, or pre-MPAT. None of the covariables were significant predictors. An expected significant ordinal treatment x grade level interaction was found.

A questionnaire was used to ascertain a measure of the students' interest in paired learning. It was determined that the student interest in paired learning was initially high (87.8%--6th and 89.3%--4th). After treatment, the interest in paired learning remained rather constant (84.7% --6th and 91.1%--4th). The sixth grade interest dropped slightly (3.1%) and the fourth grade interest increased slightly (1.8%). Durrell and Murphy (1963) indicated that eighty to ninety-five per cent of elementary school children preferred to work in teams when given the hypothetical choice. The preference of team study was often even higher following team experience. The findings generally paralleled those of Durrell and Murphy.

The interest of teachers in the program varied. Several teachers were concerned about not understanding the materials themselves. Concern over pupil movement to the sixth grade-fourth grade situation was diminished after the first day. Materials were distributed and otherwise controlled by student assistants, which released the teacher from the role of distributing materials. Several teachers noted particular interesting personality interactions. Some of the shy students became more active than usual as they gained social confidence in the paired arrangement. One teacher indicated that she never saw boys at that age work with girls so nicely. Apparently the manipulative, illustrated, auto-instructional materials were a necessary part of the paired learning. Durrell (1961)

emphasized the value of self-directing, self-correcting materials for disciplined team learning. Hartley and Cook (1967) indicated that most paired learning experiments have been completed with auto-instructional materials developed for individual students. A need was expressed for materials written for interacting students. Perhaps the measurement process materials developed for the paired learning experiment successfully allowed for student interaction and manipulation of materials.

A halo effect may have been introduced through use of manipulative auto-instructional materials (Hedges & MacDougall, 1964). Both the experimental and control group used the auto-instructional materials, however, which tended to randomize this possible internal validity jeopardizing factor.

Research Implications

The research findings reported in this paper were of a global nature. The study needs to be followed by psychological analyses of the constituent forces acting within pupil team arrangements.

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